

# ENGINEERING SPECIFICATION

## FOR

### GENERAL PROJECT REQUIREMENTS

## PUEBLO CHEMICAL AGENT-DESTRUCTION PILOT PLANT (PCAPP) PROJECT

QUALITY: <input type="checkbox"/> Q <input type="checkbox"/> Non- Q <input checked="" type="checkbox"/> NA							
002	4/26/06	Revised to Incorporate 3.1.8 Agent Containment Categories and Revised Operating Area Temperature as noted	BAP	MWM	-	PSP	
001	2/27/06	Incorporated Dr Checks' Comment # 1063274 105374, and 1056381 and revised as noted	BAP	MWM		PSP	
000	11/3/05	Revised for Redesign as Noted and Changed Document Number (Supersedes 24852-3PS-000-T0002)	BAP	MWM	-	PSP	
REV.	DATE	REASON FOR REVISION	BY	CHKD	EGS	PEM	APPR
ORIGIN			JOB NO. 24852				
Bechtel Pueblo Team			SPECIFICATION No. 24852-RD-3PS-000-T0002				REV 002
			Sheet 1 of 24				



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## **1 PURPOSE**

This specification provides background information about the Pueblo Chemical Agent-Destruction Pilot Plant (PCAPP) Project and details about the site where it is being built. Also contained in this specification are miscellaneous requirements, including a list of the prohibited and limited-use materials. This document is used as an attachment to material requisitions and subcontract requisitions. Where the terms Buyer, Seller, and purchase order are used in this specification, for subcontract requisitions, the terms Contractor, Subcontractor, and Subcontract should be substituted.

## **2 PROJECT BACKGROUND**

In 1986, Congress passed a law directing the Army to destroy the U.S. stockpile of chemical agents and munitions. The Chemical Stockpile Disposal Program (CSDP), a U.S. Army program, was established to achieve the destruction. In 1996, Congress and the President, responding to public concerns about the safe destruction of chemical weapons, established and later expanded the Assembled Chemical Weapons Alternatives (ACWA) Program to demonstrate at least two alternative technologies to the baseline incineration process for destroying the weapons. The alternative technology selected for PCAPP was a low-temperature, low-pressure neutralization and biotreatment process to destroy the chemical blister agent stockpiled in projectiles and mortars at the Pueblo Chemical Depot (PCD).

The Defense Department's ACWA program selected an integrated team consisting of Bechtel National, Inc. (BNI); Parsons Infrastructure and Technology; Battelle Memorial Institute; and Washington Demilitarization Company (WDC) to design, build, operate, and close PCAPP following destruction of the stockpiled mortar rounds containing mustard agent.

The scope of services also includes environmental permitting, equipment acquisition and installation, systemization, and pilot testing.

The Government intends to implement the project in three sequential phases:

- Phase I—Design, construction, systemization, and pilot testing to demonstrate the feasibility of the selected technology by demilitarizing a limited quantity of munitions
- Phase II—Demilitarize the remaining munitions
- Phase III—Close the site, including decontaminating and decommissioning all equipment, systems, and structures.

## **3 SITE INFORMATION**

A description of the site and details about elevation, weather, air temperature, and wind are provided in this section.

### **3.1 SITE DESCRIPTION**

PCD is located within Pueblo County in the state of Colorado, approximately 13 miles east of the city of Pueblo on SR 96 (state road 96) and 40 miles south-southeast of Colorado Springs.

Pueblo County is sparsely populated and is dominated by grazing and agricultural land. The site is characterized by flat to gently rolling hills with average slopes of less than 1 percent.

Latitude	38° 28" N
Longitude	104° 52' W

### **3.1.1 Elevation**

The approximate site elevation above mean sea level (MSL) is 4,740 to 4,760 feet.

Design absolute atmospheric pressure is 12.41 psia.

### **3.1.2 Precipitation and Storms**

The following climatological data was excerpted from the PCAPP request for proposal and supplemented by National Weather Service records for the period 1888 through 2002.

Average annual rainfall	11.8 in.
Maximum amount in 24 hours	3.77 in. (Oct. 7-8, 1957)
Highest one-month precipitation	8.13 in. (April 1900)
Rainfall in 1 hour (max)	
Once in 25 years	2.0 in.
Once in 50 years	2.3 in.
Once in 100 years	2.6 in.
Snow	
Average annual snowfall	30.3 in.
Record one-month snowfall	29.3 in. (Nov 1946)
Record one-day snowfall	16 in. (Nov 1985)
Design snow load	10 lb/ft. <sup>2</sup>
Tornado	Funnel clouds spotted, none touched down
Hurricane	None
Lightning storms	41 (highest in July); average 40/year

### **3.1.3 Air Temperature**

Following are the outdoor site temperature statistics:

Summer, dry bulb (1%)	96°F
Summer, wet bulb (mean coincident)	63°F
Summer, maximum wet bulb (1%)	67°F
	1% (for process cooling/no cooling tower used for heating, ventilating, and air conditioning)
Summer, daily range	30°F
Winter, dry bulb (99%)	5°F
Winter, wet bulb (mean coincident)	4°F

Outdoor Design Temperatures for Critical Areas (process areas of APB, ERB, LAB, control and support building [CSB] control room)

Summer, dry bulb (0.4%)	98°F
Summer, wet bulb (mean coincident)	63°F
Summer, maximum wet bulb (0.4%)	68°F 0.4% (for process cooling/no cooling tower used for HVAC)
Summer, daily range	30°F
Winter, dry bulb (99.6%)	-2°F
Winter, wet bulb (mean coincident)	-3°F

### **3.1.4 Interior Design Conditions**

Following are the site interior conditions:

- Summer Indoor Design Conditions, Maximum Temperatures
  - Toxic and process spaces with personnel\* 60°F to 85°F
  - Unoccupied toxic process areas 100°F
  - Unoccupied nontoxic process areas 104°F (or 10°F above ambient dry bulb)
  - Control room 75°F ±3°F
  - Control room relative humidity 35% ±5%
  - Battery rooms 70° to 80° F
  - Mechanical equipment room 104°F (or 10°F above ambient)
  - Electrical & UPS rooms 104°F
  - Toilets Transfer air and ventilation exhaust only
  - Offices, clinic, lunchrooms, lockers, etc. 75° to 78°F
  - Laboratory 75°F ±3°F
  - Laboratory relative humidity 30% to 45%
- Winter Indoor Design Conditions, Minimum Temperatures
  - Toxic and process spaces with personnel 60°F
  - All areas housing HD agent piping 60°F
  - Unoccupied process areas 55°F
  - Control room 75°F ±3°F
  - Control Room relative humidity 35% ±5%
  - Laboratory 75°F ±3°F
  - Laboratory relative humidity 30% to 45%

- Winter Indoor Design Conditions, Minimum Temperatures (Category D)
  - Mechanical equipment room 55°F
  - Unoccupied process area 40°F
  - Electrical & UPS rooms 55°F
  - Electrical room relative humidity 10% minimum
  - Battery rooms 70° to 80° F
  - Toilets Transfer air and ventilation exhaust only
  - Offices, clinic, lunchrooms, lockers, etc. 68°F

\*Operating range of 60°F to 75°F is the typical condition to be maintained during operations.

### 3.1.5 Winds and Frost Depth

Wind speed and direction are as listed below:

Average velocity	7 to 11 mph
Design wind velocity (gusts to be calculated)	90 mph (as per ASCE 7)
Direction of prevailing wind	East-Southeast (days) West (nights)
Frost Depth	38 in.

### 3.1.6 Available Utilities

The following utilities are available at the site:

Utility	Properties	Operating/ (Design) Temperature (°F)	Operating/ (Design) Pressure (psig)
Potable water	Underground, well water that is treated and disinfected	40 to 96/(100)	90/(125)
Potable hot water	Potable water that is heated	180/(220)	65/(125)
Process water	Recovered water from brine reduction with makeup from potable water and reverse osmosis (RO) water	80/(100)	75/(125)
Demineralized (RO) water	Treated sanitary water or potable water to <20 micro-mhos and < 1 mg/L total suspended solids (TSS)	70/(100)	75/(125)
Process cooling water	Treated sanitary water, potable water, or RO water treated with biocide, corrosion, dispersant, and scale inhibitors	80/(120)	70/(125)
Chilled water (process and	Recirculating water with 40% inhibited	44/(100)	100/(125)

Utility	Properties	Operating/ (Design) Temperature (°F)	Operating/ (Design) Pressure (psig)
heating, ventilating, and air conditioning [HVAC])	propylene glycol		
High pressure water	RO water	110/(120)	10,000/ (flange rating for class)
Hot water (HVAC)	Recirculating water with 40% inhibited propylene glycol	180/(220)	85/(125)
Steam	Potable water or RO water treated with phosphate, sulfite, and amine	337/(400)	100/(125)
Compressed (plant) air	Clean, dry, air to -40°F dew point	80/(125)	100/(125)
Instrument air	Clean, dry, air to -40°F dew point	80/(125)	100/(125)
Natural gas	Local natural gas with a heating value rated at 850 Btu/cu ft	40 to 96/(100)	50/(150)
Fuel oil	Diesel No. 2	40 to 96/(100)	30/(80)
Electrical Power	13.2 KV, 3-phase, 3 wire, with maximum 30 kA asymmetrical rms fault current. 480 VAC, 3-phase, 4 wire, with maximum 50 kA symmetrical rms fault current 208/120 VAC, 3 phase, 4 wire (solidly grounded) with maximum 10 kA symmetrical rms fault current 120 VAC, 1 phase, 2 wire (solidly grounded) with maximum 10 kA symmetrical rms fault current		

### 3.1.7 Vessel Minimum Metal Design Temperature (MMDT)

Following are the MMDTs for both indoor and outdoor use:

- American Petroleum Institute (API) vessels + 5°F
- American Society of Mechanical Engineers (ASME) vessels - 10°F

### 3.1.8 Agent Containment Categories

Categories have been established based on the potential for agent containment. The established categories are:



Hazard Category	Description
A	Areas that have routine probability of contamination, either liquid agent or vapor
B	Areas with high probably of agent vapor contamination resulting from routine operations
C	Areas with low probability of agent vapor contamination
D	Areas that are unlikely ever to have agent contamination
E	Areas maintained to be free from any agent contamination, barring a major event

#### 4 PROHIBITED AND LIMITED-USE MATERIAL

Following are the restrictions regarding use of materials in the processing areas of the agent processing building and the energetics processing building, e.g., toxic category A, B, and C areas, as indicated on the data sheets. Sellers shall provide a listing by component and equipment tag number of all of these materials used in equipment they are providing and shall include a drawing cross-reference for each component/equipment containing any of these materials.

- **Aluminum** shall be avoided wherever there is the possibility of exposure to sodium hydroxide such as during decontamination.
- **Mercury Switches** shall not be used due to the inability to obtain an environmental permit to heat the mercury in the metal parts treater during closure.
- **Batteries** shall be limited in use and, when used, shall be enclosed to prevent exposure to agent and decontamination solution.
- **Radioactive Sensors** shall not be used.
- **Lead** shall not be used, e.g., counterweights.
- **Lubricants with Sulfur** shall not be used to prevent activation of false alarms as the alarms detect agent based on the sulfur content.
- **Ferrous and Nonferrous Metal Surfaces** shall be restricted as follows:
  - In agent category A and B areas, all materials that require coating shall have coating resistant to agent and decontamination processes.
  - Galvanized surfaces exposed in agent category A and B areas shall have coating resistant to agent and decontamination processes. Coating will be required only on items located within six feet in height from the floor surface.
  - Stainless steel, chromium plate, Hastelloy, Inconel, and titanium surfaces are permitted without coating.
  - For light fixtures, electric motors and equipment, instrument controls and valves, and similar equipment, manufacturer's standard finish is acceptable.
  - In category C areas, materials without coating resistant to agent and decontamination processes may be prohibited in certain cases, which will be determined on a case-by-case basis.

- In areas containing explosive materials (Occupancy H-1 as noted in architectural life-safety drawings), floor surfaces shall be coated with non-sparking coating.
- **Petroleum-based Products** shall be limited in use in areas with the potential for agent contamination where personnel protective equipment (PPE) is used.
- **Fluoropolymers (Teflon, Viton, Kynar)** shall not be used in any service where there could be contact with agent or in any equipment that requires decontamination. They may be used in off-the-shelf components, subject to approval from the Buyer. Seller shall submit a list of components containing these materials with the proposal. No later substitution will be allowed without prior written approval from the Buyer.
- **Asbestos-containing Materials** shall not be used.

## 5 TAGGING

Tagging is required for the following: 1) shipping/receiving and construction, 2) maintenance, and 3) operations. All equipment supplied shall comply with requirements related to 1) and 2), as outlined below. Operations personnel will provide suitable tagging for operation, during the construction phase.

### 5.1 TAGGING FOR SHIPPING/RECEIVING AND CONSTRUCTION PURPOSES

For shipping/receiving and construction, tagging is required for all components, or assembled component if shipped as a unit, using stainless steel tags as described in Section 5.3, with the following precautions:

- Tags shall be as permanent as the normal life expectancy of the component.
- If stainless steel wire is used to attach the tag, the ends shall be covered with crimp clamps to eliminate any potential hazard of abrading workers' skin or cutting protective suits.
- If adhesive is used to attach the tag, it shall be verified to be chemically compatible with the tag, the component material the tag is attached to, and the expected environment. The adhesive should be chloride-free, except in trace amounts, and environmentally safe. Surface preparation and cleaning shall be done according to the directions given for the specific adhesive by its manufacturer.
- In the event tagging the individual items is not appropriate, such as packaged items in bags or boxes, the container may be identified with the tag.

### 5.2 TAGGING FOR MAINTENANCE PURPOSES

Each component of the assembly, or skid-mounted equipment, shall be labeled for maintenance purposes. When the skid is specifically built for this project, the tags shall show the unique component numbers assigned by the Buyer; otherwise the manufacturers' standard labeling is acceptable. Maintenance personnel shall be able to easily identify the particular component and cross-reference it to the maintenance manuals, diagrams, and parts lists. Manufacturer and model number of the components shall be identified in the documentation to aid replacement of parts.

### 5.3 TAGGING FOR COMPONENT DATABASE PURPOSES

Terminal boxes and instruments that have external interfaces, e.g., those that transmit signals to/from the facility control system, and instruments and valves that are shipped loose and/or require field calibration or maintenance shall be numbered per Buyer standard document numbering. The Buyer will provide the number either on the Seller's drawings or on the Seller-provided component database input list.

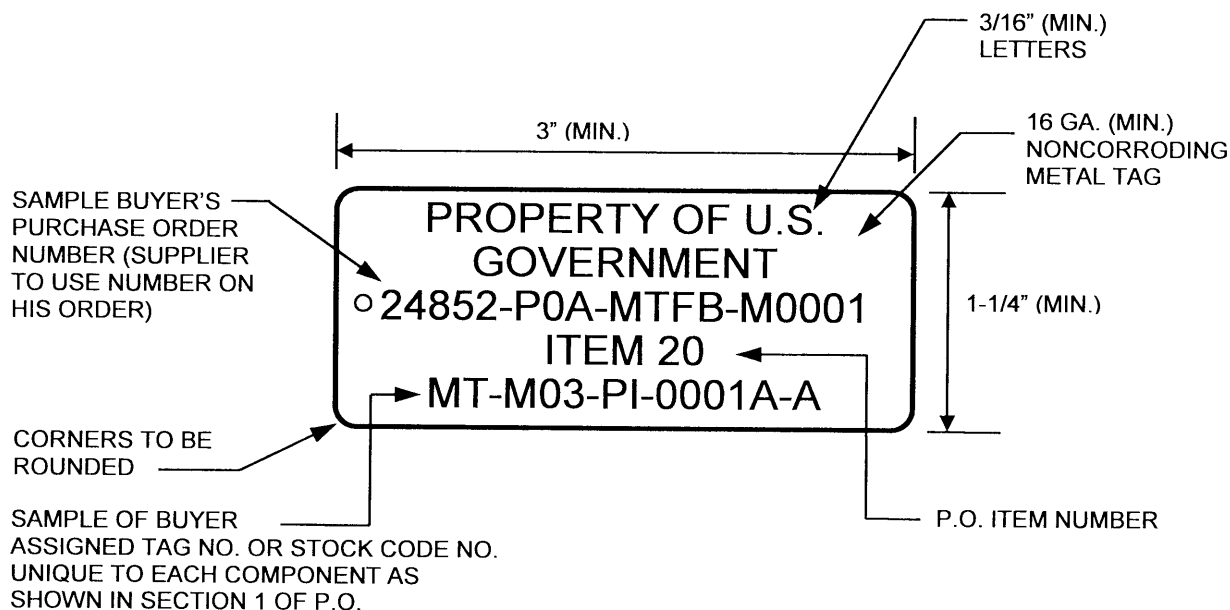
The Seller shall tag the above components with Buyer's tag number, following the requirements in Section 5.4, below, as applicable. Seller may also include a tag with Seller's tag number.

More details on component database requirements are provided in Engineering Specification for Seller Document Requirements, document 24852-RD-3PS-000-T0004.

### 5.4 TAGGING INSTRUCTIONS

All equipment, instruments, control valves, bulk item valves, electrical devices, and loose accessories shall be tagged with a noncorroding metal tag (e.g., 16 gauge, 316 stainless steel), per the sample shown below, securely affixed by pins, metal screws, or stainless steel wire.

Tagging information shall include the Buyer's purchase order (P.O.) number, P.O. item number, and Buyer's identification number, die stamped on the tag.



## 6 NOISE LEVEL REQUIREMENTS

The noise level criteria for various areas are as follows:

- 85 dBA – In rooms housing automatically operating equipment where infrequent maintenance is required (i.e., areas with greatest probability of agent contamination, referred to as category A areas)

- NC 60 – In areas where occasional communication at a distance of up to 5 feet is required (i.e., general work areas)
- NC 55 – In areas where frequent telephone, radio, or direct communication is required at a distance up to 5 feet (e.g., the control room)

Noise Criteria (NC) is defined in UFC 3-450-01 15 May 2003. This UFC supersedes TM 5-805-4. The NC number can be converted to dBA using Figure 7 Section 7.16 of 2005 ASHRAE Handbook – Fundamentals.

Unless specified otherwise in material requisitions/subcontract requisitions, equipment shall be rated at 85 dBA at three feet when measured in a free field.

## 7 SEISMIC LOADS

Seismic load requirements shall be as defined in specification number 24852-RD-3PS-000-S0001.

## 8 ALLOWABLE NOZZLE LOADS

The external piping loads (forces and moments) imposed at the connection to rotating and non-rotating-type equipment is provided in attached Tables 1 through 8. These loads are for individual load cases and are combined as normal and occasional loads. The equipment shall be capable of satisfactory operation when subjected to these loads as follows:

NORMAL LOAD CASE = Weight + Thermal (algebraic summation)

OCCASIONAL LOAD CASE = Weight + Thermal + Seismic (algebraic summation)

## 9 HUMAN FACTORS ENGINEERING EQUIPMENT CRITERIA

Special human factors engineering design guidelines and criteria are required for equipment in toxic areas (i.e., category A and B areas) that may require operations or maintenance by personnel in demilitarization protective ensembles (DPEs) (Figure 1 below). These requirements, which follow, are based on the potential exposure of personnel to chemical agents.

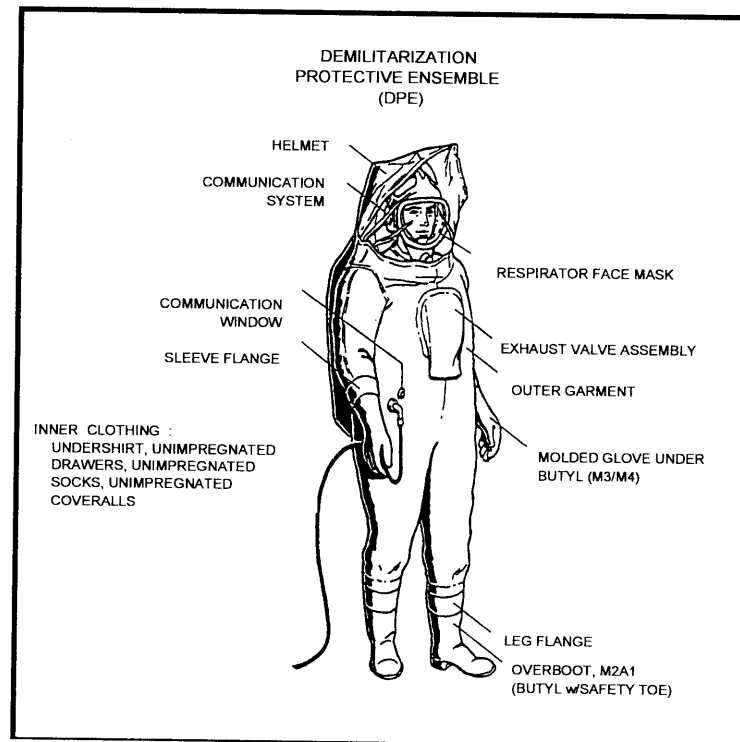


Figure 1 – Demilitarization Protective Ensemble

- **Sharp Corners:** All exposed surfaces of equipment or welded metal shall be smooth and free of any sharp edges, corners, kinks, and bends. To prevent plant operators from ripping protective gloves or suits, all exposed edges shall be rounded to 0.06-inch minimum radius, and all exposed corners shall be rounded to 0.250-inch minimum radius. Internal drum features are exempt from this requirement. All internal drum features shall be smooth. All internal surfaces shall be unable to snag a cloth when passed over the surface. Rounded edges and corners shall be ground smooth to a 125 finish. The surfaces that will be exposed to view after completion of assembly shall be neatly finished. Seams that may promote corrosion shall not be used.
- **Equipment Adjustment:** Equipment adjustments shall be minimized. When adjustable equipment is required, access to perform the adjustment shall be designed to accommodate DPE wearers. Interchangeable parts shall be designed to allow for adjustment before entry into toxic areas.
- **Connections:** Where practical, all electrical and instrumentation connections should be at a control panel or pull boxes. Spade-type wire-end connectors shall be used to avoid removal of terminal screws. Where feasible, plug-type connectors should be at control panels or pull boxes and at components with interconnecting cable.
  - No wire nuts shall be used on equipment.
  - All wires shall be color-coded and numbered. A sufficient number of spare wires shall be provided.
- **Fasteners:** Use of efficient fastener systems shall be considered for all routine tasks. Where possible, the use of wing nuts, T-handles, and Torx connections will be considered. All

fasteners shall be large enough to be handled by DPE wearers. No bolts smaller than ¼ inch shall be used on the equipment. An attempt should be made to limit the number of different bolt sizes used. Two sizes should cover nearly all applications: ¼ inch and ½ inch. Hardware fixtures using other than ¼-inch and ½-inch bolts should be evaluated to determine the feasibility of changing to the desired fastener size. These bolts shall be a standardized type, e.g., a machine bolt with standardized threads such as Unified National Course. Unsecured fasteners should be minimized to enable the DPE wearer to remove them with only one tool. This can be accomplished by several methods, such as use of inserts, floating anchor nut plates, or secured stud bolts. A self-locking device, such as Nylock, shall be incorporated into the male fastener to eliminate any requirement for separate locking washers. The male fastener locking device selected shall be standardized on all equipment. For stud bolts, the female fastener will contain the integrated locking device.

- Screws size 10 and smaller should be avoided. Size 8 and 10 screws can be handled by DPE wearers only if the length exceeds about ¾ inch. If screws must be used, they shall be standardized, such as Allen head.
- For sheet metal covers, maximum use shall be made of ¼-turn thumb screws or lock-type clamps to minimize the tool requirements. The ¼-turn thumb screw, if used, shall be attached to the remaining part of the cover plate.
- Where possible, a single size fastener shall be used for each machine.
- The maximum one-arm work reach for the location of fasteners or predicted maintenance tasks should be within 20 inches of the outside edges of the equipment. Access hole or clearance for a one-arm-reach maintenance task shall be a minimum of a 12-inch diameter equivalent at the machine's extremity. The access hole clearance can be reduced to 8 inches at the 20-inch reach point. If a two-arm maintenance task is required, the maximum reach will be reduced to 16 inches, with an access opening of at least an 18-inch diameter equivalent, reducing to 9 inches at the 16-inch reach point. Preferably, these requirements will be avoided by locating maintenance items close to the equipment extremities.

■ **Routine Maintenance:** The following shall be observed:

- All insulation applied to components that will be routinely maintained or inspected shall be removable. This covers instruments, flanges, and valves.
- All equipment with access panels for routine maintenance shall be designed for speed and ease of removal by personnel dressed in DPE.

In addition in all other areas of the plant, standard human factors engineering design guidelines and criteria shall be followed. Adequate clearances must be provided and maintained between pipe (insulated and uninsulated) and other piping systems, ductwork, structural steel, concrete, equipment, and cable trays to permit interference-free erection, maintenance, and thermal growth. Final spacing and clearances provided should permit routine maintenance and provide for the removal of any valve, equipment, and insulation without disturbing any adjacent permanent plant components. Clearance and removal space required must be indicated and reserved appropriately. Piping is not to be routed across floors, walkways, or working spaces where it could be a hazard.

Sufficient overhead clearances to the bottom of piping or pipe rack shall be followed. Equipment, instruments and wiring must be arranged for convenience of maintenance. Access to all equipment within a panel shall be provided without the need to disconnect wire or shutdown the power system. All terminals and calibration adjustments must be accessible. Instruments and indications shall be at adequate height in accordance with standard human factors guidelines.

## **10 CLOSURE**

Upon completion of the chemical agent demilitarization at PCAPP, the process buildings (i.e., agent processing building and energetics processing building) and integral support function systems will be decontaminated and decommissioned. The Seller shall include the following design features to facilitate decontamination and disassembly or size reduction, which, in turn, will allow the equipment and components to be dismantled in a reduced level of dress.

- Decontamination:
  - Access to and visibility of all surfaces or spaces where chemical agent is likely to accumulate shall be provided. Access ports or removal panels shall be provided to allow cleaning of internal surfaces by appropriate methods such as brushing, vacuuming, washing, scraping, or rinsing to remove, dislodge, or dissolve agent-contaminated particles. These ports or panels shall allow entrance and access by personnel wearing DPE.
  - Equipment internal/exterior surfaces exposed to contaminated materials shall be free of crevices, protrusions, and other irregularities that could entrap materials.
  - Overlapping of material surfaces (e.g., conveyor stands) should be avoided. If not practical, these surfaces should be sealed by welding, with internal welds ground flush with inner surfaces. Exceptions may be gasketed openings, such as inspection and cleanout doors or ports.
  - The use of multi-position or slotted mounts and equipment connections shall be minimized to reduce agent traps.
  - All welds that may be exposed to decontamination solution, explosives, and agent contamination shall be continuous, sealed, ground smooth, and flush to a 125 finish, with no ripples, undercuts, voids, porosity, cracks, or crevices.
- Disassembly:
  - Equipment shall be designed to facilitate disassembly or size-reducing into maximum 3 foot x 3 foot x 7 foot pieces during plant closure for subsequent thermal treatment to destroy residual chemical agent.
  - Equipment shall be designed for disassembly using power hand tools that are easily operable by personnel in DPE.
  - The need for portable saws and cutting torches that create cutting fumes or sparks during disassembly or size reduction should be minimized.
  - If the material of construction or its thickness lends itself to flame cutting or plasma cutting, the Seller shall provide cutting methods/tools and literature or details of personal

experience. (Abrasive water cutting is not preferred due to additional secondary waste generated.)

- The fine particles that may be generated during disassembly or cutting that may ignite or require special containment or cleanup should be defined by the Seller.
  - If disassembly of equipment into functional subassemblies is required, size and weight limitations for handling the subassemblies shall be considered, as well as lifting lugs.
  - The safety hazards that may apply to disassembly or size reduction activities that may warrant special attention should be described and provided by the Seller.
  - Any components that become pressurized during thermal treatment should be identified, and a means (e.g., puncture) to vent the pressure should be described.
- Materials: Electrical enclosures shall be metal, not plastic.

## 11 REFERENCES

24852-RD-3PS-000-S0001, Engineering Specification for Seismic Protection of Equipment

24852-RD-3PS-000-T0004, Engineering Specification for Seller Document Requirements

## 12 ATTACHMENTS

Attachment A – Allowable Nozzle Loads

Table 1 – Non-rotating Equipment – Carbon Steel

Table 2 – Non-rotating Equipment – Stainless Steel

Table 3 – Non-rotating Equipment – Titanium

Table 4 – Non-rotating Equipment – Hastelloy

Table 5 – Rotating Equipment – Carbon Steel

Table 6 – Rotating Equipment – Stainless Steel

Table 7 – Rotating Equipment – Titanium

Table 8 – Rotating Equipment – Hastelloy



Attachment A – Allowable Nozzle Loads

Table 1 – Non-rotating Equipment – Carbon Steel

CONNECTED PIPE NOMINAL SIZE	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	9	6	9	6	11	14	43	29	10	13	40	27
3/4	13	9	16	11	16	19	71	47	16	19	71	47
1	20	13	31	21	24	29	124	83	26	31	134	89
1 1/2	40	27	79	53	46	55	295	197	53	64	343	229
2	61	41	141	94	70	83	508	339	83	100	609	406
2 1/2	91	61	254	170	93	111	743	495	111	133	887	591
3	132	88	409	273	134	161	1194	796	162	194	1437	958
4	216	144	761	507	220	264	2221	1480	266	319	2679	1786
6	477	318	2028	1352	486	583	5920	3947	581	697	7080	4720
8	840	560	4051	2701	855	1026	11826	7884	1013	1215	14008	9338
10	1359	906	7283	4856	1384	1660	21260	14173	1622	1946	24920	16613
12	1906	1270	10954	7303	1942	2330	32039	21359	2213	2656	36514	24343
14	2257	1505	13313	8875	2324	2789	39763	26508	2594	3113	44376	29584
16	2878	1918	17565	11710	3011	3614	54192	36128	3254	3904	58551	39034
18	3569	2380	22406	14938	3794	4552	71299	47533	3974	4769	74688	49792
20	4332	2888	27837	18558	4673	5607	91222	60815	4753	5704	92789	61860
22	5167	3444	33856	22571	5651	6781	114096	76064	5590	6707	112854	75236
24	6072	4048	40465	26976	6730	8076	140049	93366	6482	7778	134882	89921
26	7048	4699	47662	31775	7912	9495	169203	112802	7429	8915	158874	105916
28	8095	5397	55449	36966	9198	11038	201678	134452	8430	10116	184829	123219
30	9213	6142	63824	42549	10357	12428	227208	151472	9698	11637	212747	141832
32	10402	6935	72789	48526	11401	13681	246302	164201	11231	13477	242629	161753
34	11661	7774	82343	54895	12444	14933	264127	176084	12932	15518	274475	182983
36	12992	8661	92485	61657	13478	16173	280372	186915	14820	17784	308284	205523

Attachment A – Allowable Nozzle Loads (cont'd)

Table 2 – Non-rotating Equipment – Stainless Steel

CONNECTED PIPE NOMINAL SIZE (in)	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	8	5	8	5	10	12	37	25	8	9	28	19
3/4	11	7	14	9	14	17	60	40	11	14	49	33
1	17	12	26	17	21	25	105	70	18	22	92	62
1 1/2	33	22	63	42	39	47	241	161	37	44	227	151
2	50	33	108	72	58	69	405	270	56	67	390	260
2 1/2	90	60	249	166	92	110	728	485	93	112	740	494
3	131	87	401	267	133	160	1170	780	136	164	1200	800
4	214	143	746	497	218	262	2177	1451	224	269	2237	1491
6	473	315	1988	1325	481	577	5803	3869	490	588	5912	3941
8	831	554	3971	2648	846	1016	11592	7728	854	1025	11696	7798
10	1346	897	7139	4760	1370	1644	20839	13893	1368	1642	20808	13872
12	1889	1259	10759	7173	1923	2307	31405	20937	1867	2240	30490	20326
14	2257	1505	13313	8875	2301	2761	38977	25984	2188	2625	37054	24703
16	2878	1918	17565	11710	2982	3578	53121	35414	2744	3293	48890	32593
18	3569	2380	22406	14938	3756	4507	69889	46593	3352	4022	62365	41576
20	4332	2888	27837	18558	4626	5552	89419	59613	4009	4810	77479	51653
22	5167	3444	33856	22571	5424	6509	105120	70080	4862	5835	94233	62822
24	6072	4048	40465	26976	6191	7429	118512	79008	5884	7060	112627	75084
26	7048	4699	47662	31775	6967	8360	131197	87465	7045	8454	132660	88440
28	8095	5397	55449	36966	7742	9290	142864	95243	8363	10036	154332	102888
30	9213	6142	63824	42549	8505	10206	153203	102136	9861	11834	177644	118429
32	10402	6935	72789	48526	9243	11092	161902	107935	11566	13880	202596	135064
34	11661	7774	82343	54895	9944	11932	168650	112433	13513	16216	229187	152791
36	12992	8661	92485	61657	10591	12709	173134	115423	15747	18896	257417	171611

Attachment A – Allowable Nozzle Loads (cont'd)

Table 3 – Non-rotating Equipment – Titanium

CONNECTED PIPE NOMINAL SIZE (in)	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	7	5	8	5	8	9	25	17	6	8	21	14
3/4	10	7	14	9	11	13	41	27	9	11	36	24
1	15	10	24	16	15	18	69	46	15	18	68	45
1 1/2	28	18	54	36	28	34	158	105	30	36	167	111
2	41	27	91	60	41	50	264	176	45	54	287	192
2 1/2	63	42	160	107	64	77	468	312	75	90	545	364
3	92	61	258	172	93	112	752	501	110	131	884	589
4	150	100	480	320	153	184	1402	934	180	216	1647	1098
6	335	223	1287	858	341	409	3758	2505	395	474	4354	2903
8	593	395	2582	1722	603	724	7538	5025	690	828	8615	5743
10	965	643	4660	3107	982	1179	13602	9068	1107	1328	15326	10217
12	1372	914	7082	4722	1396	1676	20673	13782	1517	1820	22456	14971
14	1656	1104	8840	5893	1685	2023	25803	17202	1783	2139	27291	18194
16	2171	1448	12145	8096	2210	2652	35449	23633	2245	2694	36009	24006
18	2764	1842	16089	10726	2813	3376	46962	31308	2752	3302	45933	30622
20	3435	2290	20708	13806	3311	3973	54182	36121	3487	4184	57065	38044
22	4187	2791	26038	17358	3763	4515	59232	39488	4409	5291	69405	46270
24	5021	3348	32109	21406	4186	5023	62851	41901	5525	6630	82953	55302
26	5940	3960	38954	25969	4561	5473	64700	43133	6888	8266	97707	65138
28	6944	4629	46602	31068	4865	5838	64444	42962	8582	10298	113670	75780
30	8035	5357	55083	36722	5069	6083	61747	41165	10741	12889	130840	87226
32	9215	6143	64424	42949	5132	6158	56275	37517	13607	16328	149217	99478
34	10485	6990	74653	49769	4993	5992	47695	31797	17672	21206	168802	112535
36	11845	7897	85796	57197	4551	5461	35674	23782	24187	29024	189595	126396

Attachment A – Allowable Nozzle Loads (cont'd)

Table 4 – Non-rotating Equipment – Hastelloy

CONNECTED PIPE NOMINAL SIZE (in)	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	8	5	8	5	11	13	39	26	12	15	46	31
3/4	11	8	14	9	15	18	64	42	19	22	80	53
1	18	12	26	17	22	27	111	74	30	36	151	101
1 1/2	34	23	63	42	41	50	256	171	60	72	371	247
2	52	34	108	72	61	74	430	287	91	109	638	425
2 1/2	96	64	266	177	98	118	777	518	153	184	1210	807
3	140	93	428	285	143	171	1250	833	224	269	1961	1307
4	229	153	796	531	234	280	2323	1549	368	441	3656	2438
6	505	337	2119	1412	514	617	6184	4123	804	964	9664	6443
8	885	590	4202	2802	903	1084	12342	8228	1400	1679	19120	12747
10	1423	949	7476	4984	1460	1753	22168	14779	2241	2689	34016	22677
12	1966	1310	10954	7303	2043	2452	33340	22227	3055	3666	49842	33228
14	2325	1550	13313	8875	2440	2929	41321	27547	3578	4293	60574	40382
16	2958	1972	17565	11710	3153	3783	56204	37469	4483	5380	79922	53281
18	3663	2442	22406	14938	3961	4753	73817	49211	5471	6565	101949	67966
20	4439	2959	27837	18558	4868	5842	94298	62865	6539	7846	126658	84438
22	5287	3524	33856	22571	5875	7050	117782	78521	7684	9221	154046	102697
24	6205	4137	40465	26976	6984	8381	144396	96264	8905	10686	184114	122743
26	7195	4797	47662	31775	8197	9836	174262	116175	10201	12241	216863	144575
28	8256	5504	55449	36966	9515	11418	207500	138334	11569	13883	252291	168194
30	9387	6258	63824	42549	10941	13129	244225	162817	13010	15611	290400	193600
32	10590	7060	72789	48526	12475	14970	284547	189698	14520	17424	331189	220793
34	11863	7909	82343	54895	14120	16944	328574	219050	16100	19320	374658	249772
36	13208	8805	92485	61657	15876	19051	376412	250941	17748	21298	420808	280539

Attachment A – Allowable Nozzle Loads (cont'd)

Table 5 – Rotating Equipment – Carbon Steel

CONNECTED PIPE NOMINAL SIZE (in)	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	4	3	5	3	6	7	22	14	5	6	20	13
3/4	6	4	8	5	8	10	36	24	8	10	36	24
1	10	7	15	10	12	14	62	41	13	16	67	45
1 1/2	20	13	40	26	23	28	148	98	27	32	172	114
2	31	20	70	47	35	42	254	169	42	50	305	203
2 1/2	45	30	127	85	46	56	371	248	55	66	443	296
3	66	44	205	136	67	81	597	398	81	97	718	479
4	108	72	380	254	110	132	1110	740	133	159	1339	893
6	239	159	1014	676	243	292	2960	1973	291	349	3540	2360
8	420	280	2026	1350	427	513	5913	3942	506	608	7004	4669
10	680	453	3642	2428	692	830	10630	7087	811	973	12460	8307
12	953	635	5477	3651	971	1165	16019	10680	1107	1328	18257	12171
14	1129	752	6656	4438	1162	1395	19881	13254	1297	1556	22188	14792
16	1439	959	8783	5855	1506	1807	27096	18064	1627	1952	29275	19517
18	1785	1190	11203	7469	1897	2276	35649	23766	1987	2384	37344	24896
20	2166	1444	13918	9279	2336	2804	45611	30407	2377	2852	46395	30930
22	2583	1722	16928	11285	2826	3391	57048	38032	2795	3354	56427	37618
24	3036	2024	20232	13488	3365	4038	70025	46683	3241	3889	67441	44961
26	3524	2349	23831	15887	3956	4747	84602	56401	3715	4457	79437	52958
28	4048	2698	27724	18483	4599	5519	100839	67226	4215	5058	92414	61610
30	4607	3071	31912	21275	5179	6214	113604	75736	4849	5819	106374	70916
32	5201	3467	36394	24263	5700	6840	123151	82101	5615	6738	121315	80876
34	5831	3887	41171	27448	6222	7466	132063	88042	6466	7759	137238	91492
36	6496	4331	46243	30828	6739	8087	140186	93457	7410	8892	154142	102761

Attachment A – Allowable Nozzle Loads (cont'd)

Table 6 – Rotating Equipment – Stainless Steel

CONNECTED PIPE NOMINAL SIZE (in)	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	4	3	4	3	5	6	19	12	4	5	14	9
3/4	6	4	7	5	7	8	30	20	6	7	25	16
1	9	6	13	9	10	13	52	35	9	11	46	31
1 1/2	17	11	31	21	19	23	121	80	18	22	113	76
2	25	17	54	36	29	35	202	135	28	33	195	130
2 1/2	45	30	125	83	46	55	364	243	47	56	370	247
3	65	44	200	134	67	80	585	390	68	82	600	400
4	107	71	373	249	109	131	1088	726	112	134	1118	746
6	236	158	994	663	241	289	2901	1934	245	294	2956	1971
8	416	277	1986	1324	423	508	5796	3864	427	512	5848	3899
10	673	449	3570	2380	685	822	10420	6946	684	821	10404	6936
12	944	630	5380	3586	961	1154	15703	10468	933	1120	15245	10163
14	1129	752	6656	4438	1151	1381	19488	12992	1094	1313	18527	12351
16	1439	959	8783	5855	1491	1789	26560	17707	1372	1646	24445	16297
18	1785	1190	11203	7469	1878	2254	34945	23296	1676	2011	31182	20788
20	2166	1444	13918	9279	2313	2776	44709	29806	2004	2405	38740	25826
22	2583	1722	16928	11285	2712	3255	52560	35040	2431	2917	47117	31411
24	3036	2024	20232	13488	3096	3715	59256	39504	2942	3530	56313	37542
26	3524	2349	23831	15887	3484	4180	65598	43732	3522	4227	66330	44220
28	4048	2698	27724	18483	3871	4645	71432	47621	4182	5018	77166	51444
30	4607	3071	31912	21275	4252	5103	76602	51068	4931	5917	88822	59215
32	5201	3467	36394	24263	4622	5546	80951	53967	5783	6940	101298	67532
34	5831	3887	41171	27448	4972	5966	84325	56217	6757	8108	114593	76396
36	6496	4331	46243	30828	5296	6355	86567	57711	7874	9448	128709	85806

Attachment A – Allowable Nozzle Loads (cont'd)

Table 7 – Rotating Equipment – Titanium

CONNECTED PIPE NOMINAL SIZE (in)	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	4	2	4	3	4	5	13	8	3	4	10	7
3/4	5	3	7	5	5	6	20	14	5	6	18	12
1	8	5	12	8	8	9	35	23	8	9	34	23
1 1/2	14	9	27	18	14	17	79	53	15	18	84	56
2	20	14	45	30	21	25	132	88	22	27	144	96
2 1/2	32	21	80	53	32	39	234	156	37	45	273	182
3	46	31	129	86	47	56	376	251	55	66	442	295
4	75	50	240	160	77	92	701	467	90	108	824	549
6	167	112	644	429	170	205	1879	1253	198	237	2177	1451
8	296	198	1291	861	302	362	3769	2513	345	414	4307	2872
10	483	322	2330	1553	491	589	6801	4534	553	664	7663	5109
12	686	457	3541	2361	698	838	10336	6891	758	910	11228	7485
14	828	552	4420	2947	843	1011	12901	8601	891	1070	13646	9097
16	1086	724	6072	4048	1105	1326	17724	11816	1123	1347	18004	12003
18	1382	921	8044	5363	1407	1688	23481	15654	1376	1651	22967	15311
20	1718	1145	10354	6903	1655	1986	27091	18061	1743	2092	28533	19022
22	2094	1396	13019	8679	1881	2258	29616	19744	2204	2645	34703	23135
24	2511	1674	16054	10703	2093	2512	31425	20950	2762	3315	41476	27651
26	2970	1980	19477	12985	2281	2737	32350	21567	3444	4133	48854	32569
28	3472	2315	23301	15534	2433	2919	32222	21481	4291	5149	56835	37890
30	4018	2678	27541	18361	2534	3041	30873	20582	5370	6445	65420	43613
32	4608	3072	32212	21475	2566	3079	28138	18758	6803	8164	74609	49739
34	5242	3495	37326	24884	2497	2996	23848	15898	8836	10603	84401	56267
36	5923	3948	42898	28599	2275	2731	17837	11891	12093	14512	94797	63198

Attachment A – Allowable Nozzle Loads (cont'd)

Table 8 – Rotating Equipment – Hastelloy

CONNECTED PIPE NOMINAL SIZE (in)	WEIGHT				SEISMIC				THERMAL			
	Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)		Forces (lb)		Moments (ft-lb)	
	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>	F <sub>lateral</sub>	F <sub>axial</sub>	M <sub>bending</sub>	M <sub>torsion</sub>
1/2	4	3	4	3	5	6	20	13	6	7	23	15
3/4	6	4	7	5	7	9	32	21	9	11	40	27
1	9	6	13	9	11	13	56	37	15	18	76	50
1 1/2	17	11	31	21	21	25	128	85	30	36	186	124
2	26	17	54	36	31	37	215	143	45	55	319	213
2 1/2	48	32	133	89	49	59	389	259	77	92	605	403
3	70	47	214	143	71	86	625	417	112	134	981	654
4	115	76	398	265	117	140	1161	774	184	221	1828	1219
6	253	168	1059	706	257	309	3092	2061	402	482	4832	3221
8	442	295	2101	1401	452	542	6171	4114	700	840	9560	6373
10	712	474	3738	2492	730	876	11084	7389	1120	1345	17008	11339
12	983	655	5477	3651	1022	1226	16670	11113	1527	1833	24921	16614
14	1162	775	6656	4438	1220	1464	20660	13774	1789	2147	30287	20191
16	1479	986	8783	5855	1576	1892	28102	18735	2242	2690	39961	26641
18	1831	1221	11203	7469	1981	2377	36908	24606	2735	3283	50975	33983
20	2220	1480	13918	9279	2434	2921	47149	31433	3269	3923	63329	42219
22	2643	1762	16928	11285	2938	3525	58891	39261	3842	4610	77023	51349
24	3103	2068	20232	13488	3492	4190	72198	48132	4453	5343	92057	61371
26	3597	2398	23831	15887	4098	4918	87131	58087	5100	6121	108431	72288
28	4128	2752	27724	18483	4758	5709	103750	69167	5785	6942	126146	84097
30	4694	3129	31912	21275	5470	6565	122112	81408	6505	7806	145200	96800
32	5295	3530	36394	24263	6238	7485	142273	94849	7260	8712	165595	110396
34	5932	3954	41171	27448	7060	8472	164287	109525	8050	9660	187329	124886
36	6604	4403	46243	30828	7938	9525	188206	125471	8874	10649	210404	140269